Robert Bell

SPECIAL REPORTS

ON

I.—Practical Notes on the Culture of Trout

II.—Peculiarities in the Breeding of Oysters

III.—The Sardine Fishing Industry in New Brunswick

BY

PROFESSOR E. E. PRINCE

Commissioner of Fisheries

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SPECIAL REPORTS.

No. I.—PRACTICAL NOTES ON THE CULTURE OF TROUT.

By Professor Edward E. Prince, Commissioner and General Inspector of Fisheries for Canada.

Fish-culture embraces methods and operations very different from each other and dependent upon the particular species or kind of fish which it is desired to artificially propagate. The operations suitable for trout are not applicable to lake whitefish or to pike-perch and black bass, nay more, the methods adopted for spawning the parent fish and hatching broods of fry are wholly different from those necessary for rearing and fattening yearlings and more mature fish.

As there is evidence of a growing desire in various provinces on the part of enthusiastic individuals to pursue private fish-culture, and to second and support the efforts of the Department of Marine and Fisheries in recuperating various waters in the Dominion, some brief notes, of a simple and practical nature, may at this juncture appear opportune.

Applications for information have reached the department at Ottawa in increasing numbers recently, and in accordance with the wishes of the Minister of Marine and Fisheries, the Hon. John Costigan, I have prepared some brief notes for the information of persons who may wish to carry on privately the culture of brook-trout.

The essential feature in the hatching of trout and salmon, whose ova are comparatively large and heavy, is the arrangement of the eggs in shallow perforated troughs over which pure fresh water passes during the period of incubation. If the eggs are loosely spread so that they do not unduly press upon each other, and if frost, excess of light, deleterious chemical or other influences are guarded against, the process of artificial hatching can be accomplished with facility. More than thirty years ago the Commissioner of Irish Fisheries hatched a quantity of salmon by a simple incubating apparatus in his office in the Customs House, Dublin—a clear proof that the obstacles to success are not serious.

Before commencing artificial fish-culture for the purpose of stocking any waters it is necessary to prove as a first step that the waters are suitable. Even streams and lakes, which once abounded with trout, may, during the process of depletion, have become altered in character, and no longer possess their former favourable features. A few adult trout transplanted from other waters will in a single season afford the required information. If the fish survive and flourish, there need be no fear of success. Such information is especially necessary in the case of artificial ponds or of waters which it is proposed to stock for the first time. Under conditions which are really unfavourable speckled trout will, of course, live, but not in a healthy, vigorous state. They will even survive in shallow stagnant water, where the supply is small and uncertain, but very different conditions are necessary for successful trout-culture.

If it is intended to hatch and rear trout from the egg the parent fish must be secured before the close season begins and retained in a pond until ripe, otherwise trout can only be secured by obtaining from the Minister of Marine and Fisheries a special permit, the conditions attached to which are very stringent. Trout, when two years old, will yield spawn, but as the number of eggs provided by them is small, and the eggs have been proved to be less hardy than those of older fish, it is preferable to select parent fish not younger than four years and not older than twelve

years. Moreover, the larger fish furnish a greater number of eggs, the amount being about 900 for every pound weight of the parent, and the eggs themselves are of larger size. A salmon produces eggs at least one-third larger than those of a small grilse, and the fry hatched from eggs of large size have been found to be finer, healthier and of more rapid growth than from smaller eggs. This is as true also of the trout. The spawning season extends over a long period, and individuals containing ripe eggs may be found from late fall until spring. It is not necessary to describe the methods of obtaining parent trout, though the drag seine of 1-in. bar, *i. e.*, about 2-in. extension mesh, is very effective. The seine being an excessively destructive net is generally prohibited in Canadian waters, however, and it must not be forgotten that the barring of small streams frequented by trout and other fish is forbidden by law.

The requisite number of parent trout having been obtained and confined in a small pond ready for artificial spawning, it is necessary for at least two operators to assist in the work, one to perform the "stripping," the other to net the fish, as required and hand the vessels, etc., to the operator. Kneeling on the ground the operator firmly but gently lifts a fish by the tail out of the landing net, using his left hand and rests its head for a moment on a towel, lightly passing his right hand towards the throat and grasping it with the open thumb and forefinger under the breast fins, the other three fingers of the right hand being pressed upon the right gill-cover of the fish. The back of the fish is pressed against the right breast of the operator and the tail bent back and upward. If the fish is fully ripe the ripe eggs will shoot out in a continuous stream and the assistant completes the operation by gently pressing upon the under side of the fish and passing his hand from the head towards the tail to expel the eggs that may not have run out. The eggs should not fall far, so that the assistant should hold or place on the left of the operator the shallow dish, which is to receive the eggs. No force is necessary. If the eggs refuse to stream out, the fish is most probably not fully ripe and a little patience will prove that. Some fish refuse for a minute or two to yield their spawn, and old fish always spawn less freely than young examples. Some manipulators wrap the fish in a towel leaving the snout and hind part of the body free, others hold the fish's head or shoulders in the left hand, and grasp the under side of the body with the right hand, holding the tail down and slightly pressing with the right thumb. There are disadvantages connected with these methods; but in all alike patience and gentle handling are essential. The fish should not be unduly disturbed or roughly treated, and spawning can thus be accomplished without the slightest possibility of injury. Very large and strong fish may demand the united efforts of two operators. When four or five female fish have been spawned into the plate yielding, say, 10,000 ova, the assistant must then land in succession two or three ripe males. Each fish should be brought close to the eggs as they lie in the plate, and as soon as the abdomen touches the eggs a large flow of creamy milt will be forcibly ejected. The plate should be turned round as each new male is brought so that all the eggs may receive a share of the fluid milt. A slight pressure of the right thumb and finger behind the breast fins and further back will increase the flow. The milt of a single male will suffice for an extraordinary number of eggs if both sexes be in fully ripe condition, and in cases of necessity one male may with confidence be used to fertilize the ova of five or six females; but where possible the first named proportion is safest. The vivifying or fertilization of the eggs will be aided by gently stirring them with a clean feather after milting, and adding half a pint of water to dilute the creamy milt. Each dish when thus filled and stirred should be placed on one side and five more females spawned into another dish. In half an hour they should be placed in a larger vessel, a clean wooden bucket, and placed under a gentle flow of clean water, to wash all impurities and excess of milt away. The eggs will appear no longer soft and yielding, and instead of clinging together will be hard to the touch and separate from each other. They are very elastic and will endure great pressure. Thus Frank Buckland, the most famous of English pisciculturists placed upon some trout eggs a weight not less than five pounds six ounces before he could crush them. Nevertheless pressure especially upon newly fertilized eggs is highly injurious.

It is necessary to place the eggs, after being cleaned, upon the hatching trays. These consist of lightly made square frames of wood, across which is stretched japanned wire cloth, though in the Government hatcheries perforated zinc trays, black japanned, have been found advantageous.

The following five conditions are necessary for successful hatching:

(1) A supply of water which is regular and unfailing.

(2) Water of even temperature, that supplied from a spring at some depth beneath the ground is preferable.

(3) Freedom from impurities and sediment, which suffocates the eggs, hence the supply of water should run into a tank to allow sediment to settle before it runs over the hatching trays.

(4) The quantity desirable is about 100 gallons per hour for 10,000 eggs. The greater the quantity of water the better, as eggs actually breathe water and need ample supplies of oxygen which the fresh inflow of water contains.

(5) Protection from floods by means of guards and an overflow ditch higher up than the supply pipe. While spring water from its equable temperature, purity and other features is always preferable, yet when incubation has advanced to what is called the eyed-egg stage, water from a brook or river will serve quite well.

Trout eggs hatch out in from 50 to 150 days, according to the temperature, amount, and rapidity, as well as the character, of the water. Water from limestone strata is generally held to be best, and the greater the quantity of water the longer can incubation be protracted. Temperature is of course most potent and a change of one degree Fahr. rise or fall, shortens or lengthens the process of incubation four or five days. Eggs of trout which hatch out in 50 days when the temperature of the water is kept at 50° Fahr., will take 100 days if the temperature is kept as low as 40°. The filled hatching trays are placed in wooden boxes open at the top, and a flow of water through the boxes must be arranged to ensure two inches or less of water over the eggs. Direct light should be excluded to discourage fungus growth. Dead eggs should be picked out each day. When eggs die they lose their delicate transparency and bloom, and assume a dead white appearance, and unless removed a feathery fungus rapidly covers the egg, and spreads to other healthy eggs. Hence the necessity for promptly removing them. If eggs require moving on the tray it should be done gently with a soft camel-hair pencil or brush. They may be softly swept into a spoon when it is desired to remove a few from the tray. A tray may be emptied by lifting it out of the water and skilfully overturning it into a dish. Eggs must never be touched by the hand, and dead eggs are best removed with wooden pincers or forceps.

Hatching and rearing boxes require to be blackened inside. Charring is much to be preferred to black varnish. Black paint must be avoided. Hot blocks of iron 20 lbs. or 28 lbs. weight are closely applied to the surface to be charred and this close contact prevents burning. All boxes, trays, &c., after charring, varnishing, &c., must be well seasoned in water some time before hatching operations begin.

When the delicate young fry, called "alevins," begin to hatch they do so in such numbers that special tanks are necessary to which to transfer them. Many of the fry cannot free themselves from the egg-shell or capsule, and require a little skilful help by means of an artist's camel-hair brush. When not more than two hours old the little fish have intelligence enough to dart away from danger. It requires some agility to capture one with a spoon. A scoop of fine gauze or perforated zinc is effective.

The following points may be noted in connection with managing the fry:

(1) They should be exposed to very little light.

(2) No food is required until the large bag of yolk attached to each alevin is almost absorbed.

(3) Prevent massing together, their jelly-like bodies when crowded together result in suffocation and death.

(4) Cover the exit with fine gauze to prevent the tail and yolk-sac of some of the fry passing through, and occasionally sweep them gently away from the point of outflow.

Before the yolk is gone, trout fry will pick up minute particles of food, but they may be fed on hard roe of flat fishes, of mackerel, or of other fish with very small eggs, which are easily scattered amongst the hungry alevins. Liver and rock-mussels finely minced form good food; but very little should be given at a time as fragments falling on the floor of the tank pollute the water. Opinions are divided as to the advantages of planting young fry, or of keeping them until a year old.

Only a small proportion can be artificially reared under the most favourable circumstances and their growth is always stunted as compared with those in their natural haunts. Early planting *i.e.*, the planting of fry within a short time after hatching and before the yolk-sac has wholly disappeared, possesses many advantages. In one well-known experiment, the fry which were planted early were found to have increased in nine days to four times the size of those of the same brood which had been confined in rearing troughs. There is no doubt also that yearlings, artificially fed, learn to trust to artificial protection and sustenance and are unfitted for the perils of natural waters when turned out. Yet, even though not more than one yearling in ten can be reared from the alevin stage, this is a great gain over natural rearing which almost certainly ensures the destruction of nine hundred and ninety-nine in a thousand fry hatched on the " redds " or natural spawning beds.

A young salmon weighs less than two grains, thus it takes nearly 250 alevins to make up an ounce, yet in sixteen months a weight of 2 oz. is reached, and twenty months later when as a smolt he has betaken himself to the sea and in a short while become a grilse of 7 or 8 lbs. *i.e.*, achieved an increase of 68 times his weight in three or four months, his advance has been most marked, and may continue until, say, a weight of 30 lbs. has been attained or an increase of 115,000 times his original weight. The rate of growth was clearly demonstrated by the late Duke of Atholl's experiments over thirty years ago when three salmon were marked by means of copper-wire around their tails. They were descending to the sea, and weighed 10, 11½ and 12½ lbs. respectively. Six months later they were retaken ascending the river from the ocean, and showed an astonishing increase in weight, viz., 17, 18 and 19 lbs. respectively.

Trout ponds for rearing and fattening purposes should be:—

(1.) Edged with charred wood, which is much better than earthen banks washed by the water.

(2.) Sloping to the north and sheltered from the east.

(3.) Not deeper than 5 to 8 feet, and shallower (say 3 feet) at the ends. The outlet should always be shallow, but trout will flourish in water 18 to 20 feet deep, though they are apt to get out of control and difficult to manage from a pisciocultural standpoint.

(4.) Sheltered so that the fish can find cool water in summer. Trees or over hanging wooden shade fences will prevent a high temperature which is injurious.

(5.) Secure from land and water-enemies, thus eels, rats, water-beetles, insects, reptiles and some birds are most destructive. Many animals and birds which never prey on fish are cruelly killed because suspected. Thus in England, the water ouzel has been mercilessly shot, though an examination of hundreds of the slaughtered birds showed that they feed only on insects and the grubs which destroy fishes eggs and young. One fish culturist published his confession that for years he had been shooting his best friends as no traces of eggs or fish had been found in the digested food of these birds. It is probable that musk-rats and other rodents live solely on leaves, roots and vegetable matters, but the real enemies of fish should be prevented from making inroads on retaining ponds.

One word of warning is necessary in view of a common opinion that German carp and other coarse fish merit the attention of fish culturists. In pure and prolific waters, such as those of Canada, abounding in trout, salmon, and all the highest grades of fish, these lower inferior kinds are a positive curse and injury if introduced. They increase fast and survive under the most unfavourable conditions: but their propagation in Canadian waters is little short of a crime, and entails the destruction

of food upon which the finer indigenous kinds live, and the crowding out of the splendid fish native to our rivers and lakes.

Even of the higher kinds, the Salmonidæ, there are species and varieties which should be regarded with disfavour, especially those from the continent of Europe. German and Austrian trout, full of the germs of disease, should not be hastily introduced, and in this connection, the words of one of the most experienced and successful fish culturists of modern times, Sir James Gibson-Maitland, of Howietown, Scotland, may be quoted as a final caution. Speaking of the changing conditions in the waters of America, and the possible decrease in the finny population, especially salmon and speckled trout (*S. fontinalis, Mitch*) Sir James Maitland says: "that nation, wise in fish culture, will soon fill their streams with trout already accustomed through centuries to the interference of man; not trout imported from the forest streams of Norway, or the mountain lakes of Switzerland, but good honest British trout, which, a hundred generations ago, made acquaintance with mill weirs and sunny streams. Civilization must breed its trout, as its cattle, or civilization will have no trout."*

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*History of Howietown, Stirling, Scotland, 1887.

II.—PECULIARITIES IN THE BREEDING OF OYSTERS.

BY PROFESSOR EDWARD E. PRINCE, COMMISSIONER OF FISHERIES FOR CANADA, OTTAWA.

When one considers the value and importance of our oyster supply, and the vastly extended efforts in the way of oyster culture during recent years, it is surprising that so little is popularly known of the main features of oyster propagation.

He would be regarded as a very stupid gardener who should attempt to grow plants, of whose flowers, seeds, and habits of growth he was totally ignorant, and the man who attempted to raise sheep or cattle without first gaining some knowledge as to their management and characteristic features, would be justly ridiculed. The cultivation of living things, animal or vegetable, terrestrial or aquatic, cannot be successfully carried on without an acquaintance with the main principles of their life, growth and propagation. In the case of oyster culture, such knowledge is the more necessary in view of the contrasts exhibited by different species of oysters, and the unlikeness in their habits and modes of multiplication.

Under specially advantageous circumstances I have been enabled to carry on investigations upon three distinct species of oyster, each distinguished by peculiarities in breeding habits which are of the highest moment.

The brief sketch, which I propose to give, of the main points brought out by my studies, may prove of practical utility and interest to many who pursue oyster culture.

It is clear that unless those who contemplate starting new oyster beds, or recuperating old depleted areas, are familiar with the main features of the mollusc's life-history some of the most hurtful influences and conditions may arise and continue without the possibility of their removal.

One point in the structure of the oyster requires reference here in order to render clear some of the descriptions which follow. The oyster, it is well to note, has, like a riding saddle, a left and a right side, with a corresponding right and left shell-valve. We speak in common language of the shell, inclosing the oyster's soft succulent body, as consisting of two halves, an upper and lower half; but, correctly described, the concave valve which is undermost is the left and the flat upper one is the right valve. The oyster lies, in fact, on its left side when clinging to its native bed. The two valves are drawn together by a thick muscle (the adductor) while at the pointed end of the shell is found a brown horny ligament or cushion-hinge, which forces the valves open when the adductor muscle is cut through or is relaxed. This dark ligament, like the horny shield of the tortoise, marks the back of the oyster. We cannot, however, truly speak of a head-end or a tail-end but the right and left sides are clearly demonstrated when the oyster is anatomically examined.

In studying oyster propagation the first important fact to be noted is this, that each oyster originates in an egg of extremely minute size. This egg is like a round ball, but soon assumes the form of a somewhat oval body. Each measures about one five-hundredth of an inch in diameter, so that five hundred of these eggs in the case of our Atlantic oyster (*Ostrea virginiana*, Lister), would cover an inch if laid side by side. The English oyster (*Ostrea edulis*, L.) produces much larger eggs, no less in fact than one-two hundred and fiftieth of an inch in diameter, or more than twice the size of the oyster's eggs in our Canadian water. In the diminutive British Columbian oyster (*Ostrea lurida*, Carpenter), which I had the opportunity of studying in 1895 on the Pacific coast, I found that the eggs were less than one-third the diameter of the English mollusc.

Each egg, in all three kinds of oysters, has the character of a minute grain of soft living matter, practically invisible to the naked eye, and unprovided with any protective shell or hard membrane. These eggs are produced by special organs in the mature oyster at a particular period known as the breeding season, to cover

which period legislative prohibitions have been enacted in all civilized countries. These special organs form a network imbedded in the fleshy body of the oyster. The network is made up of very delicate canals, with pockets or follicles at intervals, and it is in these follicles that the eggs arise. The eggs, when ripe, pass down the fine canals into a main duct on the right and left side of the oyster. These larger right and left ducts open into the fore part of a slit or depression, into which also the kidney or organ of Bojanus opens. The depression is really in the mantle cavity or general chamber of the oyster, which may be also called the shell-chamber, and it passes down close to the great adductor muscle.

Before an egg can grow into an oyster it must receive a peculiar granule of living matter, the sperm-particle, which is the male element. The egg must be regarded as a female product. When the two are fused, fertilization is completed, and the egg produces a young oyster. The sperm-particles are exceedingly minute, so small, in fact, that a myriad of them simply appear as a drop of creamy fluid. Eggs and sperms can be distinguished from each other by a trained expert without the aid of any instrument; but when magnified under a powerful microscope, the appearance of the two is wholly dissimilar. The late Professor Ryder discovered a chemical test of a very efficient character, for when using a mixture of methyl green and sanfranin, (a saturated alcoholic solution,) he found that the eggs were always coloured red, and the sperm granules appeared of a blue-green colour.

The two elements, (eggs and sperms) are formed in different individuals in our Atlantic oyster. In other words the male oyster is distinct from the female. The same holds true for the British Columbia oyster, as my researches last summer on the Pacific coast demonstrated for the first time. In the same category may also be included the Portuguese oyster, (*Ostrea angulata*, Lam.) In the European oyster, (*O. edulis*, Linn.) whose life history was, until recently, alone fully and accurately known to scientific men, a wholly different state of things exist.

In the three species referred to (excluding the European species,) when the female is ripe, the eggs travel down the tubules into the large ducts, and finally reach the cavity of the mantle, or shell-chamber, as it may be called. The eggs are so minute and light that when the oyster opens its shell, the inrush of water carries them out. They float away into the open water, and occur in such countless myriads that the surface of the sea on some oyster beds is quite cloudy with them. A female Atlantic oyster may pour forth, in a single season, fifty to one hundred millions of eggs. When shed, they have not undergone the essential process of fertilization. Only contact with the sperms produced by the male oyster can accomplish that. The eggs are, therefore, sterile, and will produce nothing unless vivified or fertilized. Now the male produces great quantities of sperms, which pass into the shell chamber just as the eggs do in the female. These sperms are simply washed out into the open water, so that they come into contact with the floating eggs, if the weather and other conditions be favourable. Countless numbers of both eggs and sperms fail to achieve this, and of course, perish. Neither eggs nor sperms, if they are kept separate, survive very long. When the egg is penetrated by a living sperm, it rapidly changes in appearance and structure. These complex changes need not be described here. They proceed while the egg, an almost invisible floating speck, is carried about in the sea. In the space of a week, more or less according to the temperature and season, the little egg becomes an active embryo, provided with a delicate shell. It soon settles down and becomes attached to any available object, preferring the shady rather than the sunny side, and remains there for the rest of its life. The late Professor Huxley kept young floating oysters for about a week, and then found that they sank and became attached to the bottom of the vessel containing them. They appeared as white discs, about $\frac{1}{20}$ of an inch in diameter. Many eggs perish because they never become fertilized; others perish after fertilization from cold or rain, or wind and gales; others again come to nothing because the place upon which they settle is unfavourable. Sand, mud, and other harmful influences also kill myriads of young, and numerous marine animals devour quanties as food. Professor Brooks, in his admirable little work on the oyster, refers to the perils of the young oyster, and quotes Möbius, that every

newly hatched European oyster has but one chance in one million one hundred and forty-five thousand, of reaching maturity. "I have shown," adds Dr. Brooks, "that the chances of each American oyster are very much less."

During my studies last year, in which I dissected and microscopically examined many hundreds of the small Pacific oyster (*O. lurida*). I found that the number of males was greatly in excess of the females. On the other hand, the sexes appear to be about equal in number in the Atlantic oyster. Careful observations have shown that the sperms produced by a single male will suffice for fertilizing the eggs of six or more female oysters. It is not necessary in this place, to give further details, as I propose to lay before the Royal Society of Canada, a special technical memoir on the subject.

It is possible that deterioration of oyster beds may arise, at times, from a serious disparity in the relative numbers of the two sexes, in the case of the Atlantic and Pacific oysters, at any rate.

Under favourable conditions, however, such is the number of sperms poured into the sea by a single male, and such is the quantity of eggs produced by each female, that the perpetuation of the beds is ensured, unless unusual circumstances intervene. One sperm suffices to fertilize a single egg.

The contrast in the propagation of the English, or rather European oyster (*O. edulis*), as compared with that of the oysters indigenous to this continent, has been referred to: but some further details are called for in order to make more clear the important differences. This is necessary in view of the fact that some of the best manuals, and many of the most eminent authorities, deal with the English oyster only, and they cannot therefore be implicitly followed in oyster culture operations in our waters. Both sexes in the European oyster, are contained in the same individual; but the eggs are not produced at the same time as the sperms. This oyster is, in fact, male at one stage, and female at another; but the eggs are found to ripen and be discharged in a short space of time, whereas the sperms may be produced over a lengthened period. Dr. Hoek has placed on record the observation that a female oyster, in which eggs were still contained in the reproductive ducts, was found to contain sperms in all stages of development about two weeks later. All investigators agree that nothing of this kind has been discovered in Atlantic oysters. "I submitted more than a thousand oysters to microscopic observation," says Dr. Brooks, "and I did not find a single hermaphrodite." It must be remembered, however, that while individuals in the European species are bi-sexual, not unisexual, yet that ova and sperms are not produced at the same time in one individual. This species is in fact physiologically unisexual, and in no case fertilizes its own ova. The fertilizing sperms must therefore be derived from other individuals. It is generally held that each oyster is at first a male and produces eggs afterwards, and this view is supported by the fact, that very young oysters have been found filled with ripe sperms. Dr. Horst found such individuals sexually mature, though barely one year old. As oysters which have acted as females begin, immediately after, to produce sperms, it is clear that in some cases there is a regular alternation in the sex-features. How often the same individual may be male and female alternately, during the same season is not known.

When producing eggs the valves of the shell are opened for breathing purposes, and sperms, floating in the surrounding water, find their way into the shell chamber, and pass to that part of the mantle cavity where the urogenital grooves are situated. The sperms are possessed of powers of active movement and enter the ducts, where they come into contact with the ripe eggs, and at once fertilize them. The eggs are thus fertilized before they reach the shell-chamber, and long before they are emitted into the surrounding water. A glutinous matter surrounds them, so that they cling to the gills of the mother oyster, which is then said to be in a state of white sickness. White spat consists of eggs enveloped in a gummy secretion, and undergoing the first embryonic changes. At the next stage about two weeks later, when the spat turns dark in colour, it is called black spat. The eggs have increased in size as well as assumed a dark tint, and they are nearly ready for emission. The spat consists in fact no longer of eggs: but of very immature embryo oysters, pro-

vided with an extremely delicate shell, and a dark brown liver, whence arises the colour characteristic of this stage. These embryo oysters are thrown out by the mother oyster as cloudy masses, which rapidly disperse in the open water. Each dark speck floats for a few days, and in calm weather sinks to the bottom, and attaches itself to any available object, dark objects being apparently preferred. Before settling down, the floating oyster may wander a long distance from the spawning beds, and in my investigations upon the Pacific coast, in the Dominion cruiser "Quadra," I captured many small embryo oysters several miles from any known oyster areas. The dangers which beset the floating young of both our two species of oysters are thus practically identical.

The European oyster does not produce more than one or two millions of eggs which are thrown out as black spat, as already described. It has therefore not one-hundredth the fecundity of the Atlantic oyster, but the young have the advantage of maternal protection until somewhat advanced, instead of being emitted into the open water, while still in the first and most frail condition. In all the species, however, a very minute proportion of the embryos or "spat" ever arrive at maturity, and apart from the perils which beset them when floating in the sea, there is always the danger that the places upon which the spat settles, or falls, may present condition fatal or at best very unfavourable. Artificial culture attempts to avoid these perils and to overcome these most serious disadvantages; but this sketch does not embrace a consideration of the conditions for successful oyster cultivation.

It remains to be added, simply, that while oysters may develop sex elements by the end of their first year, probably eggs in the Atlantic and Pacific species, though sperms only have hitherto been observed in such, and these are therefore males, yet the prime period for spat production is in the fourth and fifth year. Oysters are on many beds ready for the table in two years, and at that age the reproductive elements are formed, but they are vastly more prolific when a year or two older. In aged oysters, six to ten years old or more, the liver increases so much in bulk that the spermaries and ovaries diminish, as though crowded out. If therefore reserves of oysters in the fourth year of their growth could be secured on every important bed there need be no fear that our oyster fisheries will disappear unless natural conditions supervene, by which the original character of the beds is wholly changed.

The following summary exhibits the more important differences between our Canadian oyster and the European species:—

Canadian Oyster.

(1.) Sexes separate.
(2.) Unfertilized eggs shed by parent.
(3.) Eggs and sperm meet in the open sea and fertilisation is accomplished.
(4.) The swimming embryo is naked and has for a time no shell.
(5.) Number of eggs enormous, probably 50 to 150 millions produced by each female oyster.

European Oyster.

(1.) Sexes combined in the same individual.
(2.) Eggs never shed before fertilization.
(3.) Eggs fertilized and retained within the mother-oyster's shell.
(4.) Embryos protected by a thin shell, and emitted as "black spat."
(5.) Eggs do not exceed one to two millions *i.e.*, one egg for every hundred eggs produced by the Canadian oyster.

NOTE :—A detailed account of the Department's Oyster Culture operations by Mr. Ernest Kemp during the past year forms App. No. 10, page 227 of this Report.

III.—THE SARDINE FISHING INDUSTRY IN NEW BRUNSWICK.

BY PROFESSOR PRINCE, COMMISSIONER OF FISHERIES.

Passamaquoddy Bay, New Brunswick, and the waters around the West Isles, in the Bay of Fundy, have long yielded an abundant supply of herring. These have been commercially utilized in various ways. Formerly they were smoked or pickled and packed in barrels, but, during the last twenty years, with the decline of these branches of the fish curing industry in the province, there has grown up a sardine fishery, which has become of great importance and value.

In speaking of a sardine industry it is well to premise that the occurrence of the true sardine in Canadian seas has not been scientifically established. Sardines are fish of insignificant size, when adult, but those called by that name in Canada are, in reality, the young of the herring and allied clupeoids. The opinion expressed a year or two ago in a Quebec journal (*L'Evenement*, June 5th, 1893) by an acknowledged authority, with reference to the sardines canned on the banks of the St. Lawrence (Kamouraska) accurately represents the fact in regard to our sardines generally. "J'ai eu raison de dire qu'il n'y avait pas de sardine dans le St. Laurent et que ce que M. Letellier met en boîtes à St. André de Kamouraska n'est que du petit hareng." The small and immature condition of these fish by no means detracts from their comestible qualities. Indeed such qualities do not in all cases improve when the large full-grown stage is attained, and the adult of such clupeoids as the gaspereau is of inferior excellence, whereas the immature fish is delicate and toothsome.

The small fish, the capture of which constitutes the New Brunswick sardine fishery, are prepared and packed either in shallow rectangular tins or boxes, or in oval cans after the manner of the familiar *sardines à l'huile*, which have long formed a valuable industry in France. The sardine canneries have been chiefly, and are at the present time almost solely, carried on upon the coast of Maine. The three canneries in Charlotte County, New Brunswick, viz., that of Mr. Lewis Holmes, Beaver Harbour, Mr. Theodore Holmes, St. Andrews, and Mr. G. K. Wetmore, Deer Island, do not affect the general statement, as the pack of these establishments is but an inconsiderable item when compared with that of Eastport and other canneries.

The sardine cannery in the province of Quebec, already referred to, may be excluded from present consideration, although from the high excellence and repute of its productions it occupies a notable place in the fishery industries of the Maritime Provinces.

At or near Eastport, Maine, U. S., there are, or were until recently, no less than thirty-five sardine canneries, a number increased by the addition of sixteen new establishments to over fifty, or nearly as many as are occupied in the famous French sardine industry, packing, in 1892, 300,000 cases, which was a considerably smaller pack than in the preceding year. From season to season the number of establishments varies as new canneries are opened and old ones closed.

When the packing of sardines commenced, nearly thirty years ago, considerable quantities were put up in factories in Canadian territory. A prohibitive duty imposed by the United Ssates, wholly altered the industry from a Canadian point of view. The supplies of fish, it is true, were obtained in our waters, but the market for the manufactured article was chiefly in the United States, and by a convenient interpretation of the customs regulations, which practically would have kept out even freshly caught fish, these fish were admitted into the United States. The United States Attorney General gave the decision that Canadian boats of less than five tons burden might be regarded as not vessels in the meaning of the regulations, and the Canadian fish required for the Maine sardine canneries were thus admitted as the product of American fisheries. The United States canneries could not carry on their operations for a single day but for the ample supplies of fish obtained from

our waters, and the sardine industry, so far as our fishermen are concerned, is confined to the capture of the fresh fish and their disposal to the Maine canneries. At least ninety five per cent of the so-called United States sardines are caught by our fishermen on Canadian shores, and these are, for the most part, packed in Eastport, Lubeck and other small towns in the State of Maine.

Of such importance is the supply of these small fishes that a large proportion of the population on the Maine coast, as well as the body of Canadian fishermen who pursue their calling amongst the islands of the Bay of Fundy and neighbouring waters, may be said to be largely dependent upon the sardine industry. A failure in the supply of these fishes would mean disaster to those engaged in cleaning, curing and packing, and who have capital invested in the canneries, and would, without doubt, seriously affect the Canadian fishermen who find lucrative employment in the capture of the sardines. That the small fish, known as sardines in these waters, were abundant on the shores of Charlotte County, N.B., was long known to our fishermen, but their value was not appreciated, and the only use to which they were turned was that of conversion into manure for the purpose of fertilizing the land.

Sardines are captured in weirs (the name being pronounced "wires" in the locality), which are really walled inclosures or traps built of woven twigs, with wooden supports or posts driven into the sand at distances of six or seven feet apart, in comparatively shallow water. Smaller posts and horizontal stringers are used to secure additional strength. The weirs vary in form according to their position and the particular character of the shore. They consist essentially of a wall or leader, sometimes two or more leaders, terminating sea-wards in a pocket or trap. This pocket or trap may be circular, heart-shaped or triangular in form.

The fish, as they move along the shore, are guided by the leaders through narrow openings into the heart, and their return is prevented by projecting partitions. When once the fish reach the terminal heart they make little attempt to escape, and may be kept impounded, without suffering harm, for a period of many days, if the tide does not recede too far. Such brush weirs as just described, will last for six or seven years, but in order to avoid risk of damage by storms and drift ice in winter, many fishermen take the precaution to carry ashore a large part of the twig, wattling or brush used in the trap. The best position for a brush weir is without doubt at the extreme end of a tongue of land, especially between islands or rocky ledges, where the currents run smooth and swift.

The movement of the water when the tide flows, often carries the school directly into the trap, or when heading against the tide they are said to "stem in." As a rule the fish enter the trap at night, and on bright moonlight nights, and during the day they appear to be afraid of the weir, and as a rule, shrink from entering it. It is remarkable that the fish when entrapped, make no attempt to escape, though there are considerable spaces between the wattled twigs, especially when the weir has been recently built. Such openings become, to a large extent, filled up by weeds and debris, so that the walls of the weir, in the course of the season, increase in thickness and density, but are kept sufficiently clear to admit of free ingress and egress of water when the tide ebbs and flows. The poles and twigs, moreover, become thickly coated with mussels, zoophytes, etc., these having become attached when these creatures were in the young floating condition. Except for occasional repairs, the weir is a self-fishing device, and requires little attention. In many cases the fishermen's houses are a short distance away, but in other instances the fishermen must row a distance of two or three miles in order to secure their catch. The fish come in with the flood tide, very rarely at the commencement of ebb, and migrate into the shallows, attracted probably by food. A messenger, usually a boy, is dispatched to the weir as the water begins to lower—soon after "high-slack," during the day or after nightfall, and if he reports, on his return, that fish are in the "heart," the men, two or three, or more if the weir be very large, proceed to secure the catch. Often when the men are of opinion that the tides are "off," they omit to even inspect the weir, as they do not expect to find any fish. The catch varies greatly. Some weirs, favourably situated in narrow channels, which form favourite passages for the fish, may secure a catch worth $700 or $800 at a single

tide, the quantity of one catch on Grand Manan is reported at 400 hogsheads, *i.e.* 2,000 barrels. Fortunate lessees of weirs have realized as much as $10,000 to $20,000 in a year, as the return of a single weir; but this return is, of course, very exceptional. Storms and winds, the state of the moon, and other circumstances affect the movements of the fish, and, in consequence, the value of the catch. June, as a rule, is a moderate month, but there is often an improvement up to September. October and November are variable, but often are good, while in December the catches have been large, but in the early months of the year the fishery is not worth carrying on. So variable is the quantity of fish and the time of their appearance, that for many weeks and months it does not pay to fish the weirs. During the periods when the weirs are neglected, they must continue to catch fish of various kinds, and such fish are wasted and lost. This waste has suggested the desirability of providing a door or outlet for the escape of the fish at these times. Indeed some such provision is desirable on many grounds, for during the fishing season schools of small fish are entrapped for which there is no market, and such fish should have a means of escape provided.

The ease with which the weirs are worked tends to induce indolence and lack of enterprise on the part of the fishermen, who, unlike their brethren on the open sea, endure little hardship, labour or danger. They are not required to seek the schools of fish, but may be said simply to wait until the fish come in and entrap themselves.

The fish inside the weir pass backward and forward from end to end of the inclosure, but are not observed, as a rule, to make any attempt to escape by the open entrance, shoreward, by which they gained entrance. The interstices between the wicker work, would apparently afford means of escape, at any rate to the smaller fish, but they are observed to keep at some distance from the walls of the trap; the multitude of fish, large and small alike, move in a body backward and forward, or migrate round and round the trap. Small herring fry and post-larval silver hake often occur along with the larger fish, but these diminutive specimens, $2\frac{1}{2}$ or 3 inches in length, remain with the rest and are not observed to take advantage of the spaces and openings in the walls.

It is clear that nothing less than a spacious door, to be opened when required, will save even very minute fry from destruction. Sometimes the swift outflow of water, as the tide falls, will carry small specimens almost through the interstices, but they are observed to wriggle violently towards the centre of the inclosure and to rejoin the main school.

When the fishermen have arrived at the weir, they wait until the water has lowered sufficiently, and then proceed in the weir boats to seine the catch. These weir boats, of which two are generally used, are heavy and scow-like, measuring 15 or 20 feet in length and costing from $70 to $200.

The seine is fastened by one end to a post, usually in the deepest part of the trap, and the other end is carefully carried round, until both extremities are brought together. Thus the fish are gradually inclosed as the net is swept round. The alarmed fish rush hither and thither in great terror, as the area of the net diminishes around them, and if any risk appears that they may escape, one of the boats is rowed about in order to intercept them; the men in the meantime stamping with their feet on the bottom of the boat, and beating the water with oars and staves, driving the fish by these noises back into the pocket until finally they are massed in the bunt of the seine, and are then scooped out with capacious dip-nets. The canneries send boats round to the various points where weirs are placed and collect the fish. Fresh sardines are sold by the hogshead, equal to about 15 bushels, and the skipper of the cannery boat usually bargains for them on behalf of the factory. When several buyers are desirous of securing them a kind of auction takes place. Up to 1885 the price paid was, as a rule, $5 per hogshead; but the rate now varies extremely and may run up to $30, $50, or even $100, especially when the fish are scarce. Six dollars per hogshead is not considered a very remunerative price and when, as in rare cases, the rate has fallen to $2.50 to $3.00, the fishermen prefer to use them for other purposes than canning, and sell them for smoking. The preparation of smoked

herring was at one time an important Canadian industry, but it has fallen off to such an extent that it cannot now be regarded as other than a decaying industry. Such herring as are destined for smoking are largely shipped to Eastport, where they are smoked in United States factories by arrangements with the Canadian fishermen, in order to escape the duty of $3\frac{3}{4}$ cen's per box, levied on prepared fish shipped into the United States. Many smoking sheds in New Brunswick and Nova Scotia have been taken down and removed into Maine, but the weir fishermen receive the advantage of increased prices for fresh herring suitable for smoking. Small and undersized herring are not fitted for smoking purposes, and if too diminutive are refused by the canners who have a minimum size for the fish they handle.

The sardine factories are located along the shore in order to be easily reached by the collecting boats. It is important that the fish should be packed with little delay, or the resulting sardines will be soft, of a bad colour, and altogether inferior in quality. The factories are usually two-storey wooden buildings, provided with a wharf or landing stage. In the process of preparation, the fish are subjected to about half-a-dozen operations before they are ready for the market. The operations are largely performed by girls and youths, who, during the short season of sardine manufacture, make very large earnings. Indeed, it is said that many of the young employees in Maine work only three months in the year, and amass enough money to keep them for the remaining nine months.

The processes, briefly stated, are as follows :—

(1) The head and viscera are cut away; but the tail is not removed. This process corresponds to the "gibbing" or gutting in adult herring curing.

(2) The fish are next soaked in brine for a period of 15 to 45 minutes.

(3) On flakes, usually heated by stoves or steam pipes, the fish undergo a drying process. Unless the moisture be got rid of by efficient drying, the fish when canned are found to be spoiled.

(4) They are next cooked in oil, cotton seed or peanut oil being used. It must be remarked, in this connection, that the superiority of the French sardine, apart from the nature of the fish itself, is due largely to the use of olive oil, sometimes more or less adulterated. But in the Maine sardines inferior oil alone is used. In order to facilitate the production of superior grades of sardines, the Dominion Government permitted by Order in Council (May 16, 1893) the importation of olive oil duty free for sardine preserving—a privilege which proved highly advantageous to the "Union Sardinière du St. Laurent," and which has placed on the market canned sardines of the most excellent quality.

(5) The fish are next put through the actual packing process, being sorted and packed in oblong cases, eight or ten fish in a tin. Should this number of fish not fill the tin, they are regarded as too small, and as a rule such fish are refused by the canners.

(6) The sealing process is now executed. After being sealed, the tins are placed in a bath of boiling water for two hours. If the sealing has been done properly, and the tins are perfectly air-tight, each can should show, above and below, a concavity. When no such concavity or sinking-in appears, it is evident that the air has gained access on account of some flaw in the sealing, and the tin is at once returned to the sealer. In the larger ($\frac{1}{2}$ lb. and $\frac{3}{4}$ lb. tins) a slight puncture is made in the hot tin immediately on removing it from the bath. Through the puncture a jet of hot air escapes, and the hole is soldered up.

Formerly very small fish were accepted by the sardine canners; but these diminutive fish, twelve or more to the $\frac{1}{4}$ lb. tin, on account of their immaturity, were found to turn soft and break up when the tin was cut open. Tins presenting this bad appearance when opened caused complaints, hence the market for them ceased. Such inferior fish known as "snippers" are now rejected by the principal canners, and the weir fishermen have no encouragement to capture them.

With regard to the quality of the fish suitable for sard[illegible] manufacture, it cannot be questioned that the so-called sardines captured on our Canadian shores could hardly be excelled; but it cannot be claimed that the resulting product turned out by the United States factories in Maine have obtained a very high reputation in the mar-

kets. Quantities of sardines have been packed in oil of such inferior quality and in a manner so discreditable that they have been declared hardly fit for human consumption. One writer recently observed that "the adoption of this method has had a most damaging effect upon the well-being of the industry. Its result was to flood the market with what for a long time proved to be almost unsaleable trash. Some were packed in oil of an inferior grade, some with a very small proportion of oil of fair quality and some without any oil whatever. Of course there were numbers of good brands and brands of superior quality packed but the chief aim of a majority of the packers seemed to be to reduce the cost of production to a minimum, without regard to quality, and the consequence was to bring American sardines as a whole into disrepute in all parts of the country and abroad, wherever they had previously found a market. In the meantime competition in selling, together with the poor quality of a large proportion of the stock offered, had brought market prices down fully 50 per cent in some instances." (*Fishing Gazette*, Sept. 28th, 1895.)

In 1894 a law had been passed by the Maine Legislature with a view to remedying such a serious state of things. Amongst other regulations was one obliging every canner to use not less than one gallon of oil to a minimum quantity of sardines under pain of a considerable fine. These compulsory steps are said to have worked well, although many sardine canneries no doubt evaded the regulations, and their delinquencies escaped detected by the special inspecting officer appointed to see that the law was carried out.

As the principal run of small fish along our shores occurs in spring it is open to meet more or less effectively any abuse such as that of capturing fish too small to be utilized. "Snippers," it is true, occur in various months in summer and in the fall, but their numbers are far inferior then. Sardines should not be less than six or eight inches in length. The chief demand is for them, and fish of smaller size ("snippers") are a drug in the market. When the sardines run somewhat larger than the dimensions named they are either packed as herring, or put up in tins with tomatoes or spices or mustard. Other fish have been tried as well as the small herring, but not successfully. Smelt proved hard and dry when subjected to the various processes involved in the preparation and cooking of sardines. It must not be overlooked, however, that a new and growing industry, the canning of smelt, is now being carried on further north, enabling small smelt, not suitable for the fresh or frozen fish market, to be utilized, when taken in the usual smelt bag-nets.

What are the fish caught in the New Brunswick waters and canned as sardines?

So far as I am aware no detailed study of the smaller Clupeoids of these waters has been made, and it is possible that the so-called sardines which are caught in the weirs at one period of the year are not of the same species as those caught at another. Different species of the herring family strongly resemble each other and only the trained eye can, in many instances, distinguish them. No record appears of the occurrence in Dominion waters of the sprat (*Clupea sprattus*) though it abounds in European waters. It is an excellent and nutritious fish, though never exceeding 6½ inches in length, and usually ranging from 4 to 5 inches. It occurs in British waters during the cold winter months in immense shoals, being known in Scotland as the "garvie," and sold fresh in quantities. If these small species of the herring family occurs in our waters they must be caught in the weirs during some portion of the year. Again, the pilchard (*Clupea pilchardus*), which is the true sardine, somewhat larger than the sprat, viz., nine inches in length on an average, has not been observed off our coast. The Mediterranean sardine is smaller than that obtained on the west coast of France, and is often called *Clupea* or *Alosa sardina*; but there is every reason for regarding them as one species, inseparable from the pilchard of the Cornwall coast. No doubt also the young of the gaspereaux and the shad, not to name others of the herring family, must frequent these waters after their descent from the hatching grounds up the rivers. No observations are recorded concerning them. These surmises are made merely to show how improbable it is that merely one kind of clupeoid is caught in the weirs, and a detailed study of a large series of the small fish caught would possibly reveal in these prolific waters the existence of a species not recorded in these waters, and certainly of young forms of well-known

fishes. This surmise is rendered more probable from the fact that on a visit I made to a weir in June very small specimens of silver hake were obtained. These small fish, of a bright silvery appearance, were called small herring by the fishermen, as indeed are all small silvery fish, which are captured in the weirs. The anchovy inhabiting the Pacific coast (British Columbia) may occur off New Brunswick; indeed it can hardly be doubted that the small fish captured under the name sardine belong to many species of herring-like fish, and not one kind only. So far, few opportunities have occurred of seeing specimens captured in the weirs, but those which it was possible to obtain proved to be merely half-grown herring. The specimens examined on June 12th were taken in a weir on the south-west side of Partridge Island, St. John County, N.B. Two hogsheads only were in the weir, and a close examination was made of certain examples by removing the reproductive organs from two specimens for microscopical study. Both were females $7\frac{3}{4}$ and $7\frac{7}{8}$ inches in length, respectively. The oblong ovaries were small, not more than two inches in length, and showed the characteristic transverse folds of the developing organ. Under a high power the eggs were seen to be thickly spread through the stroma and were of minute size, the largest not exceeding $\frac{1}{10}$ inch. in diameter. The nucleus in these larger ova was of considerable diameter and occupied about one-third of the diameter of the egg, while the clear contents around contained separate oil vesicles, abundantly scattered. It is clear, both from the size of these fishes and the condition of the ovaries, that they were not more than two years old. Opinions as to the time occupied by the herring in reaching maturity have varied considerably. Some have held that seven years, others that three years, is the time, while nine months and eighteen months have been determined as the period. The life history of the herring in British seas has been fully and accurately followed in recent years. Two spawning seasons occur in the year, some individuals spawning in spring, other individuals in the fall. From the eggs, which are deposited in the bottom of the sea on rocky ground at moderate depths, young fry are hatched $\frac{1}{4}$ inch in length (5 to 7 mm.) The body is slender and transparent, sparsely spotted with black, while a large bag of yolk hangs from the under side. The larval herring develops rapidly, and has teeth and well formed breast fins when about a month old. Immense numbers of these active, worm-like young abound at the sea's surface and feed on minute crustaceans. Three months later they are still transparent and have doubled their length, and in the sixth or eighth month they measure two inches, and the sides glisten with a metallic lustre, while the head is spotted with yellow and black. They do not resemble the parent herring until three inches long. A herring four or five inches in length must be over eighteen months old, and those seven to nine inches long are probably a little over two years old and can hardly be ready to reproduce their species until their third year. The sardine industry must therefore destroy a vast number of immature herring, which eight or ten months later would be ready to spawn. The specimens examined in June had certainly never spawned, and the ovaries would hardly reach a state of ripeness until the following spring, eight or nine months la'er.

It is doubtful whether any fishery can withstand for long so serious a drain upon immature individuals. No doubt the hardy nature of the herring's eggs and fry help to keep up the numbers; but other species of fish in the sea would succumb were specimens that had never spawned captured in such vast quantities. All efforts to diminish the supply of herring here, as in Great Britain, have had apparently little effect. Some authorities have explained the non-appearance of the large winter herring in the Bay of Fundy, as for example in 1891, by the continued destruction of small fish for sardine purposes. The run of sardines also has shown at times a very marked diminution, but not more than may be attributed to the ordinary fluctuations of such a fishery. Indeed, it is a striking fact that in the years 1890-91 these small fishes were more abundant than they had been for twenty years previously.

It cannot, therefore, be said that the capture annually of vast quantities of immature fish has had any serious effects. The possibility is suggested that a considerable proportion of these small fishes may belong to other Clupeoids, though

this is contrary to the result of the examination, referred to on a prior page, and to the common opinion of those engaged in the sardine industry.

It is still an open question, therefore, whether this destruction, on a large and increasing scale is or is not calculated to ultimately endanger the supply of large herring. If schools of young are killed off before they have reached the spawning age, the general catch of the future must ere long be affected. The astonishing fact remains that in Canadian, as in British, waters, the herring fisheries have shown no signs of exhaustion, or, at any rate, no such signs as to create alarm.

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